Different GNSS (Global Navigation Satellite System) Receiver's combination and its Spatial Information Analytics

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ABSTRACT

The greater part of the modern GNSS receiver are able to guarantee a fair positioning performance almost everywhere. The aim is to investigate the effective potentialities of GNSS sensor such as GPS, GLONASS and to make a statistical analysis of these receivers. The continuous increase of the number of GNSS multi-constellation station will give a good opportunity to improve accuracy and precision levels. The system is based on sensors, Arm cortex, and personal computer. Positioning data which includes both longitude and latitude is extracted using NMEA protocol of the receiver. The extracted data will be displayed and saved on personal computer and retrieved later. Each receiver sensor is analyzed, statistically characterized and its error probabilities are obtained.

KEYWORDS: *GNSS, GPS, GLONASS, DOP, NMEA*

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I. Introduction

Navigation is a field of study that focuses on the process of monitoring and controlling the movement of a craft or vehicle from one place to another. The field of navigation includes four general categories; they are land navigation, marine navigation, aeronautic navigation, and space navigation. It is also the term of art used for the specialized knowledge used by navigators to perform navigation tasks. All navigational techniques involve locating the navigator's position compared to known locations or patterns. Modern technique for navigation includes electronic navigation. Electronic navigation covers any method of position fixing using electronic means, which includes Radio navigation, Radar navigation, and Satellite navigation. Radio navigation uses radio waves to determine position by either radio direction finding systems or hyperbolic systems, such as Decca, Omega and LORAN-C. Radar navigation uses radar to determine the distance from or bearing of objects whose position is known. This process is separate from radar's use as a collision avoidance system. Satellite navigation uses artificial earth satellite systems, such as GPS, to determine position. A satellite navigation or satnav system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision (within a few meters) using time signals transmitted along a line of sight by radio from satellites. The signals also allow the electronic receiver to calculate the current local time to high precision, which allows time synchronization. A satellite navigation system with global coverage may be termed a global navigation satellite system (GNSS). GNSS is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world. GNSS systems are currently in operation are the United States' Global Positioning System (GPS) and the Russian Federation's Global Orbiting Navigation Satellite System (GLONASS). A third, Europe's Galileo, reached full operational capacity in 2008. BeiDou-1,Chinese regional (Asia-Pacific, 16 satellites) network which will consist of 35 satellites by 2020. The Indian Regional Navigational Satellite System (IRNSS) is an autonomous regional satellite navigation

system being developed by Indian Space Research Organization (ISRO) which would be under the total control of Indian government. The Quasi-Zenith Satellite System (QZSS) satellite regional time transfer system and enhancement for GPS covering Japan.

The examination of errors figured when using GNSS is essential to know how GNSS performs function, and also to know how much error can be acceptable. The GNSS modifies the recipient clock mistakes and different impacts however some are leftover that has to be rectified. They are climatic error such as ionosphere obstruction and multipath propagation impact, large DOP values, ephemeris and clock error and disturbance that occurs in receiver. The clocks present in GNSS are very exact, but still float in little range. Lamentably, little incorrectness in clock affects a huge blunder in the position computed by the recipient. For instance, 10 nanoseconds of mistakes results in 2.5 meters of position inaccuracy. Ionosphere layer is between 90 km to 650 km over the earth. This layer consists of ions. These particles defer the signals of satellites and thus bring lot of position mistake. Normally ±5 meters, yet can be additionally increases during high ionosphere action. The troposphere layer is nearest to the Earth. Delay occurs in this layer is due to moistness, heat and barometrical weight. Multipath propagation occurs while the signal travels towards antenna. These error occurs due large buildings, trees etc, which delays the signals to reach particular antenna. Dilution of Precision (DOP) is the additional impact on satellite position determination. Large the DOP values more will be the position error occurs.

A. *Existing System*

The United States Department of Defense (DoD) has developed the Navstar GPS, which is an all-weather, space based navigation system to meet the needs of the USA military forces and accurately determine their position, velocity, and time in a common reference system, anywhere on or near the Earth on a continuous basis. GPS has made a considerable impact on almost all positioning, navigation, timing and monitoring applications. It provides particularly coded satellite signals that can be processed in a GPS receiver, allowing the receiver to estimate position, velocity and time. The U.S. Department of Defense strives to maintain the integrity and reliability of at least twenty-four satellites in the GPS network. Using GPS only, users will typically observe four to eight GPS satellites at any one time, which is adequate for determining a receiver's position in most obstruction-free environments. This cause major error in the determination of position accurately. Therefore combining GNSS receivers will increase the accuracy. Some of the major advantages of GNSS over existing GPS are

- More satellites to track, which can increase receiver accuracy and reliability
- A shorter warm-up time (known as "time to first fix")
- Reduced delay in recomposing a position if satellite signals are temporarily blocked by obstructions
- The ability to compute a position in situations that were previously too difficult for a standalone GPS receiver operation—especially near tree lines, buildings, large obstacles, etc.

II. Methodology Used To Extract GNSS Data

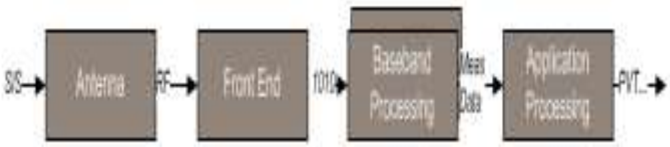

Fig 2.1: GNSS receiver architecture

Signal in space (SIS) coming from the GNSS satellite is received through antenna of the sensor as shown in figure 2.1. Radio frequency is used between 1 to 2GHZ. Data obtained will be in the form of NMEA data. The National Marine Electronics Association (NMEA) has developed a specification that defines the interface between various pieces of marine electronic equipment. Most computer programs that provide real time position information understand and expect data to be in NMEA format. This data includes the complete PVT (position, velocity, time) solution computed by GNSS receiver. The idea of NMEA is to send a line of data called a sentence that is totally self contained and independent from other sentences. All NMEA sentences is sequences of ACSII symbols begins with a '$' and ends with a carriage return/line feed sequence and can be no longer than 80 characters of visible text (plus the line terminators). Table 2.1 shows the communication configuration specifications.

Table 2.1: Configuration Specifications

Typical baud rate	**9600**
Data bits	**8**
Parity	**None**
Stop bit	**1(or more)**
Handshaking	**None**

III. Methods for using spatial data

Statistical analysis requires a combination of quantitative and qualitative analysis. Qualitative analysis is fundamental, and a quantitative analysis, which is the core of statistical analysis, is based on the precision of the qualitative analysis. According to different nature of statistical analysis contents, there are kinds of methods can be used. They are state analysis, factor analysis, link analysis, trend analysis, decision analysis, multi-level analysis.

State analysis can be subdivided into a number of different types of properties: static analysis, dynamic analysis, a state analysis of simple totality, a state analysis of complex totality. Index method can also be used for static analysis, such as analysis of the degree of completion of the project, which is a static analysis index. Factor analysis is a quantitative analysis of the factors, elements and the internal compositions that determine the development conditions of things. This is the most common analysis in statistical analysis. Socio-economic phenomena are interrelated. Causation, proportional, and balanced relations are in the presence of these associates. Correlation analysis uses the interrelated socio-economic phenomenon to analyze the numerical relations in order to study the regularity. Methods of trend analysis include both mathematical models, such as the trend line method, and non-mathematical model, such as the time expanding method and average moving method cooperating with the trend line method. Decision analysis is that people analyze, investigate, and compare different things to find optimization goals and actions to achieve program objectives optimally under certain conditions.

Some problem is relatively simple, one or two levels will be able to analyze the problem clearly. Some issues are more complex, multi-level analysis and layers of anatomy need to be used to find the nature and law issues. For multi-level analysis, each level must go through qualitative – quantitative - qualitative analysis.

A. *DOP (Dilution of Precision)*

The main purpose of stating DOP is to know about how errors may influence the last state approximation. Thus it is expressed as

$$\text{GDOP}=\frac{\Delta\text{output location}}{\Delta\text{measured data}}$$

In a perfect world little changes in the deliberate information won't bring about vast changes in yield area, in that capacity an outcome would demonstrate the arrangement is extremely sensitive mistakes. If the satellite in view are far apart DOP value will be high, if the satellite in view are close together DOP will be low. Table 3.1 shows the DOP values explanations. DOP includes HDOP (Horizontal Dilution of Precision), VDOP (Vertical Dilution of Precision), PDOP (Position Dilution Of precision), TDOP (Time Dilution Of Precision). The impact of satellite geometry in the position blunder is known as geometric DOP. For instance consider a pyramid structure formed by joining satellites from the receiver end. Larger the volume good DOP values will be getting, smaller the volume worst DOP value will be obtained.

B. *DOP Calculation*

HDOP (Horizontal Geometric Dilution of Precision), GDOP, PDOP and VDOP can be known by geometry of the present satellites from the view of receivers. DOP values will be worse by the obstacle such as large buildings, vehicles etc. In order to compute DOP values, consider x, y, z as position of receiver and x_i, y_i, z_i position of the satellite i. Thus matrix Y is given by

$$A=\begin{bmatrix}\frac{(x_1-x)}{R_1} & \frac{(y_1-y)}{R_1} & \frac{(z_1-z)}{R_1} & -1\\ \frac{(x_2-x)}{R_2} & \frac{(y_2-y)}{R_2} & \frac{(z_2-z)}{R_2} & -1\\ \frac{(x_3-x)}{R_3} & \frac{(y_3-y)}{R_3} & \frac{(z_3-z)}{R_3} & -1\\ \frac{(x_4-x)}{R_4} & \frac{(y_4-y)}{R_4} & \frac{(z_4-z)}{R_4} & -1\end{bmatrix}$$

The initial three components of the column of A are the parts of a unit vector from the recipient to the showed satellite. The components in the fourth segment are c which means the speed of light which is always one. If it is -1 then it should be computed properly. Formulate matrix Q, as

$$Q=(Y^T\,Y)^{-1}$$

Where Q is given by

$$Q=\begin{bmatrix}\sigma_x^2 & \sigma_{xy} & \sigma_{xz} & \sigma_{xt}\\ \sigma_{xy} & \sigma_y^2 & \sigma_{yz} & \sigma_{yt}\\ \sigma_{xz} & \sigma_{yz} & \sigma_z^2 & \sigma_{zt}\\ \sigma_{xt} & \sigma_{yt} & \sigma_{zt} & \sigma_t^2\end{bmatrix}$$

Thus PDOP, TDOP and GDOP can be calculated as

$$PDOP = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2}$$

$$TDOP = \sqrt{\sigma_t^2}$$

$$GDOP = \sqrt{PDOP^2 + TDOP^2}$$

Table 3.1: DOP ranges explanation

DOP Value	Rating	Description
<1	Ideal	Highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurement are considered accurate enough to meet all but the most sensitive application
2-5	Good	Represents a level that marks the minimum appropriate for making business decisions. Positional measurement could be used to make reliable in-route navigation suggestion to the user
5-10	Moderate	Positional measurement could be used for calculations, but the fix quality could still be improved. A more open view of the skyis recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a veryrough estimate of the current location
>20	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6- meter accurate device (50 DOP * 6 meters) and should be discarded

C. *HDOP versus VDOP*

Large the number of satellites utilized as a part of the arrangement, littler the DOP values and subsequently littler the error. An accurate HDOP values without error occurred will be between one and two. VDOP contains the value higher than HDOP. VDOP is more because the signal is received above the receiver. This indicates that position error occurs more due to VDOP. HDOP performs less error because signals are received from all the sides. If the earth were transparent to radio waves, then vertical directions would have same exactness as horizontal coordinates. VDOP accuracy can also be progressed by using accurate clock at the receiver. HDOP and VDOP values are also affected by higher latitudes (north or south) values. This is because number of satellites for view in high region will be low. The main reason, the satellite can incline only for 55 degrees that is, it is not at all possible to get the satellite directly at latitude north of 55 degrees north (or south of 55 degrees south). DOP values will still be more even if the satellites are more in mid latitude, because of heavy forest. This obstruction does not allow tracking the signals.

IV. Conclusion and Future enhancement

Global Navigation Satellite Systems (GNSS) technology has become vital to many applications that range from city planning engineering and zoning to military applications. It has been widely accepted globally by governments and organizations. The impressive progress in wireless communications and networks has played a great role in increasing interest in GNSS and providing enabling methodologies and mechanisms. Thus if there is a necessary of accurate positioning, combined receiver should be used than GPS or GLONASS alone. The GNSS can be future enhanced for indoor environment. This can be done by impressive progress in wireless communications and networks in increasing interest in GNSS and providing enabling methodologies and mechanisms.

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